

# Contents

Preface	v
1 Ion-Stimulated Processes	1
1.1 Interaction of Light Ions with Single-Crystalline Semiconductors	1
1.1.1 Elastic collisions	4
1.1.2 Inelastic collisions	9
1.1.3 Radiation defect formation in semiconductors under the influence of accelerated ions	12
1.2 Proton Enhanced Diffusion	16
1.2.1 Dopant redistribution in semiconductors under high temperature proton irradiation	16
1.2.1.1 Detecting of the proton-enhanced diffusion	16
1.2.1.2 Theoretical presentations about the influence of the proton irradiation on the impurity diffusion in semiconductors	22
1.2.1.3 Vacancy model of the enhanced impurity diffusion	25
1.2.1.4 Two flux model of proton-enhanced diffusion	31
1.2.1.5 Proton-enhanced diffusion of ionized impurities	38
1.2.1.6 Applied aspects of proton enhanced diffusion	50
1.2.1.7 Proton enhanced diffusion in the quantum-scale heterostructures	51
1.2.1.8 Near-surface proton enhanced diffusion	53
1.2.1.9 Long-distance effects by proton enhanced diffusion	57
1.2.2 Impurity diffusion into a preliminarily irradiated semiconductor crystal	60
1.3 Processes of Ion Beam Mixing	72
1.3.1 Theoretical concepts of the physics of radiation enhanced processes at the metal–semiconductor interface	72
1.3.2 Ion implantation-stimulated processes of the formation of chemical compounds	76
1.3.3 Quantum well and quantum dot proton irradiation-induced intermixing	83

2	Transmutation Doping of Semiconductors by Charged Particles .....	86
2.1	Nuclear Reactions Involving Charged Particles .....	87
2.2	Simulation of Transmutation Doping by Charged Particles .....	88
2.3	Experimental Investigation of Transmutation Doping by Charged Particles .....	96
2.3.1	Silicon .....	97
2.3.2	Semiconductor compounds A <sup>III</sup> B <sup>V</sup> .....	100
2.3.3	Other materials .....	106
2.4	Potential of the Method of Transmutation Doping with Charged Particles in the Technology of Semiconductor Devices .....	109
3	Doping of Semiconductors using Radiation Defects .....	112
3.1	Doping of Gallium Arsenide and Other III–V Semiconductors .....	112
3.1.1	Production of radiation defects in gallium arsenide .....	113
3.1.2	Radiation defect formation in indium phosphide .....	122
3.1.3	Effect of proton irradiation on the electrical properties of III–V compounds .....	125
3.1.4	Prospects of using proton irradiation for the development of semiconductor devices based on III–V compounds .....	136
3.2	Doping of Silicon with Radiation Defects .....	143
3.2.1	Radiation defects in silicon irradiated with protons and alpha particles .....	143
3.2.2	Energy levels of radiation defects in silicon irradiated with protons and alpha particles .....	144
3.2.3	Production rates and concentration profiles of radiation defects in silicon irradiated with protons and alpha particles .....	151
3.2.4	Implementation of radiation with protons and alpha particles in the technology of Si-based devices .....	158
3.3	Doping of Narrow Bandgap Semiconductors with Radiation Defects .....	166
3.4	Doping of Wide Bandgap Semiconductors with Radiation Defects .....	170
3.4.1	Radiation-induced defects in GaN and related compounds .....	170
3.4.2	Doping of SiC with radiation defects .....	180
4	Formation of Buried Porous and Damaged Layers .....	188
4.1	Formation of Buried Nanoscale Porous Layers in Semiconductors .....	188
4.2	Use of the Porous Layers in the Technology of Semiconductor Devices .....	195
4.2.1	“Smart-Cut” technology .....	195
4.2.2	Gettering of impurities by porous layers .....	223
4.2.3	Proton beam micromachining .....	228
	References .....	230
	<i>Index</i> .....	252